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SEISMOLOGY FROM A MATHEMATICAL VIEW-POINT¹

By Professor W. D. CAIRNS

oberlin college

THE high honor attaching to the office of vice-president of the American Association for the Advancement of Science demands a worthy effort on an occasion like the present. Very properly a general consideration of some field within the scope of mathematics may come under review, and all the more will this be appropriate for a section of the American Association if it links itself to some other department of science. I am therefore returning to an old-time love of mine and considering to-day the advance that has been made in seismology within, let us say, the last thirty years.

At first sight the phenomena to be studied seem hopelessly confused; the ground effects near the origin of

the earthquake show buffeting blows from all directions; earthquake records, even those of the same earthquake, often look widely different; and the layman wonders what can be made of these happenings as a science. It is, however, the glory of the human mind that it can select, classify, analyze, and can thus bring order out of chaos.

The universe is a system, a unit,
Only in the mind of man.

[The speaker described (1) the evident mechanism of earthquakes consisting of a gradually increasing strain and subsequent fracture of the rock structure; (2) the transmission of the shock, the longitudinal and transverse wave through the earth and a wave of greater amplitude over the surface; (3) various reflected and refracted waves; and (4) methods for obtaining information about velocities below the surface,

¹ Address of the retiring vice-president and chairman of the Section on Mathematics, American Association for the Advancement of Science, Richmond, December 28, 1938. The address was illustrated by a large number of slides.

the depth of the earthquake focus and of various discontinuities below the earth's surface.]²

Wiechert³ had by 1907 determined from the three components the angle of emergence of *P* and *S* waves where they meet the surface of the earth as a table giving the sine of this angle compared with Δ , the epicentral distance, and had plotted the velocity at the vertex (the deepest point of the path) against the depth of the vertex. He had thus prepared the way for the theoretical treatment made by Herglotz in 1907 and accepted even now as the method for determining the paths of the waves through the earth's interior. Seismologists have always assumed Snell's law that in passing from one medium to another of a different density the angles of incidence and refraction are connected with the velocities in the two media by the relation $\sin i_1 / \sin i_2 = v_1 / v_2$. Fermat's principle that a wave travels from one point to another in the least possible time, and an assumed law of dependence of velocity on depth, will determine the path, the travel-time in terms of epicentral distance, etc. Happily Herglotz recognized that conversely, with a few natural assumptions such as an increase of velocity with depth, the data furnished by a travel-time curve give a unique solution for the paths of the waves and for such incidental relations as that between the maximum velocity and the depth of the vertex. For those sufficiently conversant with mathematics, it may be said that Herglotz⁴ in February, 1907, recognized Benndorf's⁵ formulation of May, 1906, as an integral equation of the form

$$\Delta = \frac{2R}{V_\Delta} \int_{x=a}^{x=b} \frac{d \log r}{(x-a)^{\frac{1}{2}}},$$

R earth's radius; r radius to a point of the path; $x = 1/V_r^2$; $a = 1/V_\Delta^2$; $b = 1/\bar{v}^2$; v_r vel. at the point of the path; $V_r = \frac{v_r R}{r}$; \bar{v} vel. of wave as it emerges at earth's surface; V_Δ component of \bar{v} along earth's surface. Herglotz gave as its solution:

$$\log R/r_v = -\frac{1}{2\pi R} \int_b^x \frac{V_\Delta \Delta da}{(a-x)^{\frac{1}{2}}},$$

r_v radius of vertex; and Wiechert⁶ in 1910 simplified it thus:

$$\log R/r_v = \frac{1}{\pi R} \int_0^\Delta q d\Delta,$$

$\cosh q = V_r / V_\Delta$.

The computation, which by this formula gives the radius of the vertex of any path in terms of the epi-

² For discussion of these points see, e.g., Macelwane, "Theoretical Seismology," New York, 1936.

³ E. Wiechert, Gött. Nachr., math.-phys. Kl., 1907.

⁴ G. Herglotz, Phys. Zeitschr., 8: 145-147, 1907.

⁵ H. Benndorf, Mitt. d. Erdbeben Komm., 29, 1905; 31, 1906; Sitzungsber., 114, 1905; 115, 1906.

⁶ E. Wiechert, Phys. Zeitschr., 11: 302, 1910.

central distance, as well as the velocity at the vertex, depends essentially on an estimation of the slope of an accurate travel-time curve at various points and on a graphical integration. While the method now used is precisely that of 1910, the improvement in the reliability of records and in technical ability to interpret these records has enabled seismologists within the past ten years to utilize a greatly increased mass of records and to obtain results far more reliable than formerly.

Numerous ingenious methods have been developed for the determination of deep foci. These all depend on the fact that the travel-time curve of any phase varies somewhat with the depth of the focus, as Serase⁷ in 1931 indicated in his *P* and *S* curves drawn for several different focal depths. Brunner⁸ draws the *P* curve for an earthquake occurring at the surface, a curve slightly lower than this for the corresponding *P* wave if the depth of the focus were 100 km, a curve slightly higher than the first for the wave *pP* reflected from the earth near the epicenter for a focal depth of 100 km, with similar pairs of curves for 200 km, 300 km, . . . 700 km and a similar set of curves for *S* and some other phases. If then, as in the illustration which was shown, the *pP*, *S* and *sS* phases occur later than the *P* phase by 1 min. 15 sec., 10 min. 18 sec., and 12 min. 43 sec., these are marked on a straight strip of paper according to the time scale and the strip is fitted uniquely to the Brunner chart, indicating in this special case an epicentral distance of 90°, a depth of approximately 340 km and the additional fact that the earthquake originated 12 min. 24 sec. before the time of arrival of the *P* phase. Depths up to 700 km have been determined for both light and heavy earthquakes.

From the information available in 1926 Daly⁹ inferred that heavy shocks originate at depths less than 25 miles and that the occasional shock at depths greater than 40 miles may mean that the material below that depth is of the nature of hot glass and not crystalline rock. Such conclusions as to the composition of the earth have been based on a questionable extrapolation; but these conclusions have been gradually revised because of data that give much fuller information as to the depth of strong and weak shocks, and they can now be modified much more reliably by reason of such heavy-pressure work as that of Bridgman through the attainment of laboratory pressures of 50,000 atmospheres or approximately 50,000 kg/cm² corresponding to a depth of perhaps 160 km if we make a reasonable assumption of density.

The dependability of records from good instruments is unquestioned, as is evidenced by almost identical

⁷ F. J. Serase, Proc. Roy. Soc., A, 132, 1931.

⁸ G. J. Brunner, "Earthquake Notes," Eastern Sec., Seism. Soc. of Amer., 1934.

⁹ R. A. Daly, "Our Mobile Earth," pp. 116, 119, New York, 1926.

seismograms of the same shock on instruments of similar instrumental constants used at the same station or of similar instruments in the same general region. There has been a decided gain in the clearness of records and in the greater control over a wider range of magnification.

This discussion divides itself as between theory and practice; and it becomes manifest at once that the applicability of seismological theory depends on the advance made in observational instruments and methods and in their trustworthiness.

SEISMOMETERS

It is probably well known that a seismometer consists of a so-called "steady mass" suspended delicately through a flat spring or a pivot on a framework which is rigidly attached to the ground, preferably to solid rock. It is suspended so as to move freely, say, east and west; a compressional wave coming from the west will displace the ground and framework toward the east, but the steady mass will lag on account of its inertia and will therefore appear to move toward the west, its relative motion being magnified by mechanical means and recorded on a roll of smoked paper as in the Milne and Wiechert types, or magnified by galvanometric means and recorded photographically as in the more recent types. To furnish a record at a really complete station it is necessary to have three instruments to register the vertical, the north-south and the east-west motions, respectively, as well as to record waves of both short and long periods.

(The speaker here described the leading types, contrasting the older and newer instruments.)

Much intensive work has been done in California the past six years in the study of near-by earthquakes by means of "accelerometers," i.e., instruments which are designed to register not displacements or velocities but accelerations. Lack of time prevents any discussion of this study, which is so important in relation to construction that shall withstand earthquake shocks and in furnishing data for the mathematical treatment of disturbances close to the epicenter. Nor can attention be given here to the great progress being made in the seismological exploration for oil deposits, or to the study of microseismic movements which obscure the records in varying degrees and which have yet to be correlated successfully with meteorological or other phenomena, even after thirty-five years of research.

INTERPRETATION OF RECORDS

An amazing amount of highly creditable investigation has been given during the past thirty years to the mapping out of various "phases" of earthquake waves. This involves the determination of the exact time at which a sharp change in the record takes place,

and exceedingly critical examination and comparison of many records of the same earthquake and of similar earthquakes so as to establish a definite continuity in the progress of this suspected phase as the epicentral distance increases. The travel-time curves of such phases and the accumulated evidence of velocities at varying depths below the earth's surface throw light on the probable path through the earth. In particular, the very complete analysis by Jeffreys¹⁰ in forming his travel-time tables shows a high grade of mathematical work, as measured by the very small standard errors of his results; its dependability is limited only by his data, since he, like others, made an arbitrary but judicious choice from the available earthquake records. To be sure, seismologists, like our national economists to-day, sometimes form consistent and well-authenticated theories, which fail, however, to agree with those of other equally qualified experts; nevertheless, there is a gratifying agreement as to the real existence and travel-time of the more important phases, along with a great improvement in the time control and accuracy of time determinations.

AN APPRAISAL OF THE FIELD

Numerous attempts have been made to apply harmonic analysis to the study of seismograms either on account of the quasi-periodic character of the curves or on an assumption of periodic motion of the earth for a short interval. (Slides were shown of two complex curves not entirely dissimilar: one of a seismogram imitated quite closely years ago by Professor D. C. Miller by the combination of thirty harmonic curves, another as the combination of ten harmonic curves, also by Professor Miller; the second was, however, not a seismogram but the note of a clarinet!) The fallacy in this sort of analysis is that the theory of harmonic or Fourier series analysis resolves a curve uniquely into harmonic constituents only where there is a periodic motion, ever so complicated, perhaps, but with a definite and sustained period. About all that has been done along this line is for an expert seismographer to sketch a curve through a complicated seismogram which evidently shows a wave of longer period and of large amplitude, superposed on which are smaller waves of shorter period. The instant reaction of the mathematician to this procedure, however, is that if such a curve is legitimate in practical interpretation; i.e., if there is actually a wave of this character, some mathematical theory should be developed which will correspond to this postulated reality. While several have presented criteria for the existence of such a periodic wave, the science of seismology is still very much undeveloped at this point.

One line of evidence on which any theoretical inter-

¹⁰ H. Jeffreys, *Beitr. d. Geophysik*, 1936; Mo. Notices, Roy. Astr. Soc., *Geophys. Suppl.*, 4, 1937-1938.

pretation must be based is the amount of displacement of the ground at any station and hence its frequency or possible periodicity, its amplitude, etc., as inferred from the records of its three components. These curves are quite unlike. The usual formula for a damped pendulum whose support is disturbed by a blow, or by a sustained motion of the earth, furnishes theoretically the relation between the displacement on the seismograph record and the ground displacement, both for mechanical and for galvanometric registration. Formulas for these two leading types of seismometers are exhibited here:

Equation of mechanical photographic seismometer:

$$V \frac{d^2x}{dt^2} = \frac{d^2a}{dt^2} + 2\epsilon \frac{da}{dt} + \left(\frac{2\pi}{T_0}\right)^2 a.$$

x is ground displacement; a is record displacement; ϵ is damping factor; T_0 is natural period of pendulum; V is magnification for very short waves. The solution is given by

$$Vx = a + 2\epsilon \int_{t_0}^t adt + \left(\frac{2\pi}{T_0}\right)^2 \int_{t_0}^t dt \int_{t_0}^t adt.$$

From this equation it follows that a seismometer measures displacements, velocities or accelerations of the ground motion according as the period of a wave is much less than T_0 , intermediate in value, or much greater than T_0 . Both graphs and nomograms are available for finding the magnification, whether the record indicates an obvious period or only an impulse.

Equations of galvanometric seismometer:

$$\begin{aligned} K \frac{d^2\phi}{dt^2} + D \frac{d\phi}{dt} + U\phi &= ML \frac{d^2x}{dt^2} - Gi \\ k \frac{d^2\theta}{dt^2} + d \frac{d\theta}{dt} + u\theta &= gi \end{aligned}$$

x = ground displacement; ϕ = angular displacement of steady mass; θ = angular displacement of galvanometer coil; i = current intensity. From these is derived a rather complicated expression for magnification.

Since any disturbance is ordinarily damped out on the record within half a vibration, it is theoretically possible, on each of the three components, to take account of the manner in which magnification depends on the period of the wave at any instant and to draw a record of the actual displacement of the ground through mechanical or graphical integration and thus by comparing the three components to know, for example, whether the wave at any moment is longitudinal, transverse or screw-like, whether it occurs in a horizontal or vertical or oblique plane or in no plane, whether it is a periodic motion continuing for several seconds or for a few minutes, i.e., whether the earth in any limited region has a so-called "proper motion," or whether, on the other hand, there appears to be no analyzable motion aside from the leading phases al-

ready mentioned. Here is where, in my judgment, a proper advance has not been made in the past thirty years. Even conceding that promising trials have been made by Gutenberg, Sharpe and others, we must have in mind that Wiechert began this as early as February, 1901. There should even at the present day be closer agreement and greater dependability in the calculation of ground displacement and ground motions. For example, Sharpe interprets the same record by two different methods as giving at one instant displacement measurements so diverse as 93μ and 63μ at a distance of $72^\circ.6$, 62.4μ and 30.1μ at $77^\circ.5$, etc., although he has much closer agreement from 80° on. Moreover, within the past two or three years doubt has been thrown¹¹ on the formulas used in the Galitzin-Wilip and other types, the observed magnification being in some instances 50 per cent. larger than the theoretical, probably because of the reaction of the coil of the galvanometer on the motion of the steady mass. If a more critical study than has yet been made of this whole class of trials throws doubt on the validity or applicability of the formulas taken from mathematical physics, it is of prime importance that scholars highly qualified in applied mathematics should correct the older methods or develop new and correct ones. It is also undoubtedly true, as more than one careful observer has said, that too much of routine station work is unreliable except for the good indication of times of arrival of the various phases. Only 20 per cent. of the records which Sharpe¹² collected were usable for ground motion study, and a similar criticism was made in 1936 by Gutenberg and Richter.¹³ Much more than is now the case should instruments be kept in adjustment, the records and the instrumental constants be uniformly well taken so that onsets, amplitudes, periods may be obtained reliably.

The first P phase and its immediate successors are more readily studied than the S or L phases because they are less overlaid and hidden by waves already on the record. There are, however, many accurate records where the S phases enter as measurable impulses and where consequently fairly definite conclusions should have been made as to the nature of these waves. It appears to me, after a careful study, that the most that has been accomplished in the past thirty years is agreement that the S phases are approximately transverse, usually polarized, i.e., vibrating in a plane, but that this is only a rough first approximation. For example, to suggest the complexity of the situation, Macelwane shows an S phase which appears first as a westward impulse, then as a southward impulse and then (approximately nine seconds later) as an upward impulse with

¹¹ Wenner and McComb, *Bull. Seism. Soc. of Amer.*, 26, 1936.

¹² J. A. Sharpe, *Bull. Seism. Soc. of Amer.*, 25, 1935.

¹³ Gutenberg and Richter, *Beitr. d. Geophysik*, 47, 1936.

a similar condition in the next two or three half-oscillations; hence this must be more nearly a helical motion, the energy vector pointing first upward, then eastward, etc.

It is worth while noting that several seismologists have collected and analyzed data which convince them that the core of the earth does transmit transverse waves, a conclusion which, if well founded, will modify interpretations as to the earth's interior.

With regard to the *L* or surface waves, it is only fair, in a critical review such as this, to say that these are the most difficult to measure for the reasons that much is happening on the record already, that surface waves are less uniform due to the heterogeneity of the geological surface structure and that the trace frequently runs off the record or onto adjacent lines of the record. In the same breath I feel impelled to say that remarkable progress has been made during these years in the deciphering of complex records and in the recognition of various *L* phases, and that more might have been expected in determining the nature of these waves.

Rayleigh long ago showed the mathematical possibility of surface waves whose intensity decreased rapidly with the distance below the surface, a sort of skin effect, the energy of which decreased inversely as the square, rather than the cube, of the epicentral distance. But in this type of wave a particle on the surface would vibrate with a retrograde movement in an ellipse elongated *vertically* in a plane passing through the path of the wave while the observed motion is much more commonly in an ellipse elongated *horizontally* and has a strong component at right angles to the path. A second type of surface wave, the Love wave, has a sound mathematical basis, but serves only incompletely to correspond to the waves which it was supposed to represent. Whether other types mathematically possible can be found that will conform to the observed types or whether some more general, and unfortunately more complicated, theory must be used, there is here a large field for the highest kind of research. I think I am correct in saying that, except for Uller's¹⁴ theory and perhaps Sezawa's or Gutenberg and Richter's, very little of worth has been done on the theory of earthquake waves in the past thirty years. My own prediction is that the simple elasticity theory in use almost unchanged for the past fifty years of the history of seismology must be modified along the line of what in optics is called the theory of dispersion or possibly by the use of a theory somewhat like that now employed in atomic theory. Gutenberg said in 1935: "Recent investigations have shown that in most regions—perhaps everywhere—we do not have one homogeneous surface layer, but a few with slightly different properties, and that, besides, the

thickness of these layers and even their properties are different in different regions. . . . It seems to be probable that differences found by different authors are due more to the use of different earthquakes than to differences in the methods used by them." In some details we must expect each earthquake to give its own characteristic record and even each station to have its own individual record of each earthquake. Much attention should be given in the immediate future to comparing the records of specific stations with the accepted "average" curves so as to identify as much as possible the variant characteristics of each station, in the hope of ascertaining the variations in local structure.

One greatly contested question is whether the period of seismic waves is independent of distance or whether, on the contrary, the irregular waves tend to smooth out, just as when an object is thrown into water. Gutenberg, Galitzin and others have in the past adduced evidence that there is no change of period with distance, but in 1923 Macelwane¹⁵ from the records of 66 stations pointed out that both short and long *P* waves tend to approach a uniform prevailing period. Gutenberg in 1934–35 found that for all types of curves the prevailing period at a station increases as the station distance increases. In my opinion, there is a sufficiently large supply of trustworthy records so that this could be definitely decided by two or three experts, criticizing each other's findings. The classical theory of elasticity takes no account of possible change of period. But this is a question of prime importance in seismological theory; if there be such a progressive change, due to viscosity or other cause, some able mathematical physicist must develop a suitable theory.

If, as I believe after a consideration of the evidence concerning waves through the deeper parts of the earth's interior, we include in our study what are undoubtedly variations in their behavior at these depths also, and if we accept the usual postulate that a shock is transmitted from a focus to a distant point in the least possible time, we must conclude that the major portion of an impulse, as measured by intensity, amplitude, acceleration or other mathematical characteristics, will go from one point to another along such paths as are now accepted, but that, because of variations in structure along these paths, a minor part will be scattered over paths which differ slightly from the main path and will differ more or less from the main phase in time and direction of arrival and will show smaller amplitudes and intensity and slight differences in phase, period, etc. Thus a phase will appear on a record as a rather sharp change or impulse, but surrounded by small variations which, so to speak, cluster somewhat irregularly about the main impulse. It is

¹⁴ K. Uller, *Beitr. d. Geophysik*, 18, 1927 and later vols.

¹⁵ J. B. Macelwane, *Bull. Seism. Soc. of Amer.*, 13, 1923.

analogous to the appearance of a point of light which appears through clear glass as a point but through slightly ground glass as somewhat diffused owing to the small irregularities caused by the grinding. Whether these variations will be amenable to such successful treatment as, for example, the statistical study of travel-time curves by Jeffreys, must be answered according to our states of mind, ranging, in Gutenberg's facetious phrase, from his own optimism to Macelwane's pessimism!

The whole subject of seismology is complex, somewhat as the field of economic or sociological phe-

nomena; it grows out of and depends on a variety of superposed causes and elements and is therefore especially difficult of analysis. In its applications to seismology, mathematics must examine not merely its validity but its sufficiency, for in this field its sufficiency is the measure of its validity. In closing, we can only join with the Countess in "All's Well that Ends Well":

Will your answer serve fit to all questions?

.....
It must be an answer of most monstrous
size that must fit all demands.

OBITUARY

CALVIN BLACKMAN BRIDGES

THE death of Calvin Blackman Bridges on December 27, 1938, is a serious loss to genetics and also a personal loss to his many friends. Taking part from the beginning in the *Drosophila* investigations that started at Columbia University about 1910, he became, after obtaining his doctorate, a member of the small group supported by a grant from the Carnegie Institution of Washington. He was still a member of the staff at the time of his death. During these twenty-five years Bridges made a long series of contributions that won him wide recognition as an outstanding genetic investigator.

He was born in 1889, at Schuyler Falls, New York State, and his early years were passed near Plattsburg, N. Y. Beginning as an undergraduate at Columbia he was my private assistant from 1910 to 1915, and fellow 1915-16, taking his Ph.D. in 1916. As stated above he was a member of the "Carnegie Group" 1915-38. In 1936 he was elected to the National Academy of Sciences.

A bare list of the titles of his papers from 1913 to 1938 would give some idea of the nature of the many contributions he has made. His paper on non-disjunction has become a classic; it adduced convincing evidence that chromosome movements furnish the mechanism of heredity. This evidence rested both on observational work and genetic experiment. What seemed at first an exception to accepted genetic interpretations turned out a brilliant confirmation of them—the exception that proved the rule.

Bridges' early discovery (1917) that certain genetic data could be interpreted as due to deficiencies in the chromosome-construction has led in recent years to a factual demonstration of such deficiencies. In some of his latest work (1937-38) he made use of this discovery in the interpretation of overlapping deficiencies to demonstrate the characteristics of certain mutant types. It would be hard to find in the history of genetic research a more convincing demonstration of

the combination of factual evidence and masterly interpretation of it. As early as 1919 Bridges described "duplication" as a chromosomal aberration, and here, as in his other work, his conclusions rested not on guessing or vague hypotheses but on experimental proof. Much later he also reported the occurrence of "repeats" in the normal chromosome which will have to be seriously considered in future interpretations of certain types of genetic behavior.

His work on sex determination was a brilliant venture into a more theoretical field, although here, too, it is important to observe that there was no idle flight of speculation but an adherence to actual evidence based on his own thoroughgoing observations. His interpretation of the effects of tetraploidy, triploidy, haploidy on the constitution of the individual is an outstanding contribution to the theory of sex determination in such forms as *Drosophila*, where the outcome is not complicated by the presence of sex hormones in the conventional use of this expression. This work led him to a theory of gene balance that applies not only to problems of sex determination but more broadly to gene balance involving the physiology of phenotypic expression. His interpretations of balance in sex determination in particular inclined him to believe that it is unwise, i.e., not in accord with the evidence at hand, to look for a male-producing and a female-producing gene, this being too naïve a way of expressing the facts, which are more probably due to balance of many kinds of genes more or less widely distributed in the chromosomes. This does not mean that some genes may not be more influential than others in regulating the development of one or the other sex, which may well be the case, but the search for genes concerned only with sex has up to the present not been successful.

In recent years Bridges has spent much time in revising the genetic maps which are the standard ones wherever *Drosophila* is used. His work here was more than a routine job, for he devised ingenious methods to meet some of the statistical problems involved. The

discovery of the large striated chromosomes of the cells of the Malpighian tubes and of the salivary glands of Dipteran larvae by Heitz and Bauer and by Painter in 1933 opened the way for demonstrating some of the earlier conclusions reached by genetic analysis. They pointed out the constancy in the seriation of the banding along these chromosomes, and Painter emphasized the point to point apposition of the two homologous strands. He also went further and demonstrated the identity of particular sections of the salivary chromosomes with particular sections of the genetic map by utilizing the available materials for translocations, deficiencies and inversions. Bridges (1935) then made an elaborate study of the salivary chromosomes, and his more recent work has more than doubled the number of visible bands. These maps bid fair to become the standard ones for *D. melanogaster*. It should be pointed out that the identification of the salivary bands with the genetic map would not have been possible were it not that during the preceding twenty-three years the genetic maps had been built up to a point where such comparisons had a real, demonstrable basis. While many workers had contributed to bring the genetic maps to their status in 1933 it was Bridges in particular who had made a more detailed and critical study of the maps than had any single one of his contemporaries. It is generally recognized that the building up of stocks, containing efficient combinations of genes suitable for special genetic problems, was carried out by Bridges. Any one who is familiar with the labor and ingenuity involved in making such combinations will realize what a very great assistance Bridges has given to the workers in this field.

In the course of the 25 years that the map-making has been going on, more than 900 stocks have been constructed that are invaluable for the pursuit of many genetic problems. There is no other material comparable with this, and to-day the "Carnegie Group" is faced with the responsibility of maintaining these cultures, each of which is carried in three-fold for safety. This work involves most careful supervision to insure the purity of the material; for experience has only too well shown that if not carefully watched the stocks may deteriorate. These stocks are available to-day for research work anywhere in the world and have been widely used.

Since 1934 Bridges and Demerec have printed for private distribution (under the auspices of the Carnegie Institution of Washington) nine large volumes called "Drosophila Information Service" that bring together the vast amount of work in this field up to date. This undertaking was arduous in the extreme, and I am afraid it overtaxed Bridges and diverted him to some extent from his more important pioneering work. He has left behind a very large amount of unpublished data. Fortunately the requirements of

the Carnegie grant were such that each year a report of progress had to be made (see Reports Nos. 15-37). In consequence the twenty-three reports give in briefest summary the results that Bridges had obtained. Whether the elaborate data, that are on file, on which these reports rest, can ever be fully utilized is questionable; but Bridges accomplished so much other work they will not be needed to place him amongst the leading geneticists of his time.

T. H. MORGAN

HENRY VAN PETERS WILSON

HENRY VAN PETERS WILSON, Kenan professor of zoology in the University of North Carolina, died in Duke Hospital, Durham, N. C., on January 4, 1939, and was buried at Chapel Hill on January 6, a few weeks prior to his seventy-sixth birthday. He was born in Baltimore, Maryland, on February 16, 1863, and was a son of the Reverend Samuel A. Wilson and Sophia Anne Stansbury Wilson.

Professor Wilson was educated in the schools of Baltimore and Johns Hopkins University. Following graduation from Hopkins in 1883, he was registered for a short time in the Medical School of the University of Maryland, but soon found that his interests were primarily in biological science rather than in clinical medicine. He transferred to the graduate school of Johns Hopkins and began work in zoology under Professor W. K. Brooks, who at that time was drawing into his laboratory a number of able young men. Under the inspiring tutelage of Professor Brooks, and in company with these eager fellow students, many of whom have since added luster to American science, H. V. Wilson worked for a number of years. He received the degree of doctor of philosophy in 1888 and continued at Hopkins as Bruce fellow until 1889. From 1889 to 1901 he worked at Woods Hole in the laboratory of the U. S. Fish Commission.

In 1891 Dr. Wilson, then a young man of twenty-eight, went to the University of North Carolina as professor of biology. With the separation of the departments of botany and zoology in 1904 he became professor of zoology, and he continued as head of that department until 1936. He became Kenan professor of zoology in 1917. At Chapel Hill Professor Wilson soon came to be recognized as a critical and inspiring teacher. Severe discipline and rigorous thinking became outstanding characteristics of his department. His insistence on thorough scholarship and his enthusiasm for research, shared by a number of his young colleagues, were important influences in laying the foundation for a tradition of creative scholarship in what was then a small isolated institution with an honorable history but suffering from the post-war poverty of the South. This enthusiasm for research and for building up the facilities for research caused

him to exert his influence towards the establishment of the U. S. Fisheries Laboratory at Beaufort, N. C., and he served as director of it from 1898 to 1901. This laboratory was always near to his heart, and he spent many happy summers there engaged in the investigation of problems of marine biology.

Throughout his long productive life he was nearly always working but never hurried. Despite a heavy load of teaching and administrative duties, his research accomplishments are impressive. He was one of the foremost authorities of the world in the classification of the sponges, and some of his papers in other fields are classical. It is appropriate to mention here his work on the embryology of the sponges, coelenterates and lower vertebrates and his dramatic and widely known work on the regeneration of sponges and coelenterates from dissociated cells. Just a few months before his death he reported to the National Academy of Sciences his final fundamental research dealing with the participation of vacuoles in the formation of cell membranes.

Dr. Wilson's qualities of character and mind made him a vivid and forceful personality and a delightful and stimulating companion in his hours of relaxation. Simple in his habits, inherently and inescapably honest, he had no patience with pretense or complacency. His opinions and criticisms were searching and straightforward, sometimes to the point of sharpness, but, being kindly and tolerant by nature, he gained not only the respect but the affection and devotion of all those who knew him well. Although primarily a biologist, his intellectual interests were far-ranging. The writer, who was closely associated with him for several years, recalls with a feeling of stimulation and pleasure how his incisive mind would cut through the superficialities investing any subject and how his comments would illuminate a wide variety of topics.

Although he was not aggressive for publicity and honors, Dr. Wilson's merit was recognized by his fellow biologists throughout the world. He served as president of the American Society of Zoologists and was a member of the National Academy of Sciences, American Philosophical Society, American Society of Naturalists, Boston Society of Natural History, Société Linnéene de Lyon, etc.

In 1893 he married Edith Theresa Stickney, of Boston. He is survived by two daughters, Mrs. Thordike Saville, of New York City, and Mrs. Howell Peacock, of Philadelphia, and by one son, Dr. H. V. Wilson, Jr., of Dover, Delaware.

W. C. GEORGE

RECENT DEATHS AND MEMORIALS

DR. ALBERT SAUVEUR, emeritus professor of metallurgy and metallography at Harvard University, died on January 26 at the age of seventy-five years.

PROFESSOR JOHN HENRY SCHAFFNER, since 1911 professor of botany at the Ohio State University, with which he had been associated since 1897, died on January 27 at the age of seventy-two years.

DR. EDWARD SAPIR, since 1931 professor of anthropology and linguistics at Yale University, died on February 4 at the age of fifty-five years.

DR. GEORGE H. Girty, geologist and paleontologist of the U. S. Geological Survey, a specialist on carboniferous formations and faunas, died on January 27. He was sixty-nine years of age.

PROFESSOR RALPH CLEMENT BRYANT, a member of the faculty of the Yale School of Forestry, since 1911 as professor of lumbering, died on February 1 at the age of sixty-two years.

ARTHUR N. LEEDS, research associate in botany at the Philadelphia Academy of Natural Sciences, died on January 26 at the age of sixty-eight years.

EDGAR HERBERT WELLS, since 1921 president of the New Mexico School of Mines at Socorro, N. M., committed suicide on January 8. He was fifty-one years old. Mr. Wells had been professor of geology and mineralogy of the college from 1917 to 1925 and state geologist from 1925 to 1927.

FORMER associates of the late Dr. T. Wingate Todd, professor of surgery of the School of Medicine of Western Reserve University, who died on December 28, held a memorial service in his honor on January 15. Dr. Elliot C. Cutler, professor of surgery of Harvard University, formerly of Western Reserve University, and the Hon. Harold H. Burton, Mayor of Cleveland, gave the principal addresses.

SCIENTIFIC EVENTS

THE NATIONAL HEALTH PROGRAM

A NATIONAL health program, which would provide for expenditures by 1949 of up to \$850,000,000 annually from state and Federal funds, was recommended to President Roosevelt last July by his special Inter-Departmental Committee on Health and Welfare. While the proposal stirred up some opposition in medical circles, the American Medical Association agreed

last September with the Inter-Departmental Committee that there is a vital need for an extension of existing medical facilities, and Senator Wagner has prepared a bill calling for an appropriation of \$50,000,000.

Money appropriated for the health program would, according to recommendations, be used to:

Pay physicians to care for those too poor to afford medical care; assist existing hospitals and build new ones

where needed, particularly in rural areas; establish clinics for quick diagnosis and treatment of disease; encourage vaccination against preventable diseases.

Develop maternal and child welfare facilities, including baby clinics, schools for expectant mothers, visiting nurses and obstetrical care if needed.

Stimulate public health service to control disease through such activities as controlling stream pollution, establishing more efficient quarantines, health instruction for both children and adults and closer inspection of milk and water supplies.

Funds would be allotted to states and communities under restrictions requiring that they do their part in health promotion.

In submitting the program to the Congress on January 23, President Roosevelt sent the following message:

In my annual message to the Congress I referred to problems of health security. I take occasion now to bring this subject specifically to your attention in transmitting the report and recommendations on National Health prepared by the Inter-Departmental Committee to coordinate health and welfare activities.

The health of the people is a public concern; ill health is a major cause of suffering, economic loss and dependency; good health is essential to the security and progress of the nation.

Health needs were studied by the Committee on Economic Security which I appointed in 1934 and certain basic steps were taken by the Congress in the Social Security Act. It was recognized at that time that a comprehensive health program was required as an essential link to our national defenses against individual and social insecurity. Further study, however, seemed necessary at that time to determine ways and means of providing this protection most effectively.

In August, 1935, after the passage of the Social Security Act, I appointed the Inter-Departmental Committee to Coordinate Health and Welfare Activities. Early in 1938, this committee forwarded to me reports prepared by their technical experts. They had reviewed unmet health needs, pointing to the desirability of a National Health Program, and they submitted the outlines of such a program. These reports were impressive. I therefore suggested that a conference be held to bring the findings before representatives of the general public and the medical, public health and allied professions.

More than 200 men and women, representing many walks of life and many parts of our country, came together in Washington last July to consider the technical committee's findings and recommendations and to offer further proposals. There was agreement on two basic points, the existence of serious unmet needs for medical service; and our failure to make full application of the growing powers of medical science to prevent or control disease and disability.

I have been concerned by the evidence of inequalities that exist among the states as to personnel and facilities for health services. There are equally serious inequalities

of resources; medical facilities and services in different sections and among different economic groups. These inequalities create handicaps for the parts of our country and the groups of our people which most sorely need the benefits of modern medical science.

The objective of a National Health Program is to make available in all parts of our country and for all groups of our people the scientific knowledge and skill at our command to prevent and care for sickness and disability; to safeguard mothers, infants and children, and to offset through social insurance the loss of earnings among workers who are temporarily or permanently disabled.

The committee does not propose a great expansion of federal health services. It recommends that plans be worked out and administered by states and localities with the assistance of federal grants-in-aid. The aim is a flexible program. The committee points out that while the eventual costs of the proposed program would be considerable, they represent a sound investment which can be expected to wipe out, in the long run, certain costs now borne in the form of relief.

We have reason to derive great satisfaction from the increase in the average length of life in our country and from the improvement in the average levels of health and well-being. Yet these improvements in the averages are cold comfort to the millions of our people whose security in health and survival is still as limited as was that of the nation as a whole fifty years ago.

The average level of health or the average cost of sickness has little meaning for those who now must meet personal catastrophes. To know that a stream is four feet deep on the average is of little help to those who drown in the places where it is ten feet deep. The recommendations of the committee offer a program to bridge that stream by reducing the risks of needless suffering and death, and of costs and dependency, that now overwhelm millions of individual families and sap the resources of the nation.

I recommend the report of the Inter-Departmental Committee for careful study by the Congress. The essence of the program recommended by the committee is federal-state cooperation. Federal legislation necessarily precedes, for it indicates the assistance which may be made available to the states in a cooperative program for the nation's health.

SCIENTIFIC RESEARCH AND THE FEDERAL GOVERNMENT

THE importance of scientific research and the part played in research by the Federal Government were emphasized in a report by the National Resources Committee transmitted to the Congress by President Roosevelt on January 23. The study was directed by a Subcommittee on Research of the Science Committee, consisting of Charles H. Judd, University of Chicago, chairman; William F. Ogburn, University of Chicago, and Edwin B. Wilson, Harvard University. Other members of the Science Committee are: Ross G. Harrison, Yale University, chairman, National Research

Council; John C. Merriam, formerly president of the Carnegie Institution; Waldo G. Leland, secretary of the American Council of Learned Societies; Harry A. Millis, University of Chicago; Walter D. Cocking, University of Georgia, and Edward C. Elliott, president of Purdue University.

In his letter of transmittal to the Congress, President Roosevelt wrote:

The dependence of civilization on science is universally recognized, but the extent of the activities of private and public agencies carrying on scientific inquiry is not generally known.

It is not likely that large numbers of our people have any adequate realization of the services which are being rendered by the executive agencies of the Federal Government through scientific researches in medicine, agriculture, economics, public administration and the other natural and social sciences.

This report indicates the new emphasis in recent years on activities in the social science fields and stresses the need for effective coordination of all agencies engaged in research in order to achieve the solution of many of our more difficult problems.

The report, entitled "Research—A National Resource," the first of a series in this field, was prepared by the Science Committee of the National Resources Committee and covers the relations of the Federal Government to the problem, while later studies will be concerned with research by universities and colleges, by business organizations, by the large industrial laboratories and by state and municipal governments.

The Federal Government, according to the report, spent on research approximately one dollar for each person in the United States during the fiscal year ending June 30, 1937. The \$120,000,000 spent in this field, however, represented only about 2 per cent. of the total budget, in contrast to industrial corporations which spend about 4 per cent. of their budgets on research and universities which spend as much as 25 per cent. The number of professional and scientific workers employed by the Federal Government, under the Classification Act, from 1924 to 1937 has doubled.

The seven recommendations are made by the committee as follows:

1. That two studies be made to supplement those reported in this volume, one of the advisory committees which now cooperate with federal research agencies and one of research carried on by states and municipalities. The latter study may well enlist the cooperation of the state and regional planning boards.

2. That steps be taken to improve the methods of recruiting research workers for governmental service and to provide more effective in-service training for civil employees of the government.

3. That research agencies of the government be authorized and encouraged to enter into contracts for the prosec-

cution of research projects with the National Academy of Science, the National Research Council, the Social Science Research Council, the American Council on Education, the American Council of Learned Societies and other recognized research agencies.

4. That official recognition and, where necessary, financial support be given by the government to international meetings of scientists, and that American participation in international organizations and projects be encouraged.

5. That research within the government and by non-governmental agencies, which cooperate with the government, be so organized and conducted as to avoid the possibilities of bias through subordination in any way to policy-making and policy-enforcing.

6. That research agencies of the government extend the practice of encouraging decentralized research in institutions not directly related to the government and by individuals not in its employ.

7. That the interrelations of governmental research agencies be furthered by the organization of central councils along the same lines as those exhibited by the existing national councils of research specialists. These inter-agency councils would serve to systematize the efforts which are now made by various interbureau committees to coordinate the research activities within the government.

LINCOLN'S BIRTHDAY CELEBRATION FOR DEMOCRACY AND INTELLECTUAL FREEDOM

A LUNCHEON was held at the Columbia University Faculty Club on January 23, under the auspices of the New York City Committee of the Lincoln's Birthday Committee for Democracy and Intellectual Freedom. Professor Franz Boas announced that the national committee, consisting of twenty-eight scientific men from all parts of the country, including two Nobel Prize laureates and twelve members of the National Academy of Sciences, are sponsoring public meetings in metropolitan and college communities throughout the country on Lincoln's birthday on February 12.

It is the purpose of these meetings, which are an outgrowth of the Manifesto on Freedom of Science signed by 1,284 scientific men, to show that workers in science and education are ready to participate actively in the defense of democracy and intellectual freedom.

The master meeting will be held in the grand ballroom of the Waldorf-Astoria Hotel in New York City at 1:30 P.M. on February 12. Secretary of Agriculture Henry A. Wallace will speak on "Racial Theories and the Genetic Basis of Democracy." Arrangements have been made to broadcast the addresses over the Red Network of the National Broadcasting Company. Other speakers will be Professor Harold C. Urey, of Columbia University; Dr. Ordway Tead, president of the New York City Board of Higher Education, and Professor Clyde R. Miller, of Teachers College, Columbia University.

At the University of Pennsylvania Roland Morris, formerly U. S. Ambassador to Japan, will preside. The speakers will include Dr. Edward P. Cheyney, professor of history at the University of Pennsylvania; Dr. Marion Park, president of Bryn Mawr College, and Dr. E. G. Conklin, professor emeritus of zoology, Princeton University, and executive vice-president of the American Philosophical Society. In Boston, Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, will preside at a similar meeting, and at the University of Illinois, the meeting, sponsored by seven members of the National Academy of Sciences, will be presided over by Professor Roger Adams.

Plans are under way for meetings at the University of California, Stanford University, the University of Wisconsin, the University of Nebraska, the University of Oklahoma, Purdue University, the University of Kentucky, Miami University, the University of Virginia, Duke University, Connecticut State College, Dartmouth College, Syracuse University, the University of Pittsburgh and other institutions.

THE SECOND ANNUAL WILLIAM LOWELL PUTNAM MATHEMATICAL COMPETITION

PROFESSOR W. D. CAIRNS, secretary of the Mathematical Association of America, announces that the second annual William Lowell Putnam Mathematical Competition will be held on March 4, 1939. This competition was held for the first time last April, and aroused much interest among colleges and universities in the United States and Canada, sixty-seven of which entered one hundred and sixty-three competitors. At that time the University of Toronto won the \$500 first prize, with the University of California and Columbia University winning the \$300 second and \$200 third prizes, respectively. Individual winners were scattered over the continent and were about evenly divided between colleges and universities.

Colleges and universities may enter teams of three or individual contestants; applications may be secured from the Secretary of the Mathematical Association of America and must be filed with him by February 15, 1939.

The competition consists of two three-hour examinations, constructed to test originality as well as technical competence. Questions will be taken from the fields of calculus (with applications to geometry and mechanics), higher algebra, elementary differential equations and geometry.

The first prize is \$500 to the department of mathematics with the winning team; second and third prizes are \$300 and \$200, respectively. Each member of the three winning teams receives \$50, \$30 or \$20 according to the standing of his team.

Each of the five highest-ranking individuals receives a prize of \$50, and from this group is selected the one

to receive the \$1,000 William Lowell Putnam Prize Scholarship at Harvard University (or Radcliffe College, if the winner is a woman). Medals also are awarded to the five highest-ranking individuals as well as to the members of the three winning teams.

Honorable mention will be given this year to the three departments whose teams rank next after the winning three and to the five individuals ranking next after the winning five.

The competition, open to undergraduates in colleges and universities of the United States and Canada, is made possible by the trustees of the William Lowell Putnam Intercollegiate Memorial Fund, left by Mrs. Putnam in memory of her husband, a member of the Harvard Class of 1882. It is designed to stimulate a healthful rivalry in undergraduate work in mathematics.

Complete details concerning the rules of the competition will be found in the January, 1938, issue of the *American Mathematical Monthly* and in pamphlets being distributed to colleges and universities in the United States and Canada. All correspondence should be sent to W. D. Cairns, secretary of the Mathematical Association of America, Oberlin, Ohio.

AWARDS OF THE GEOLOGICAL SOCIETY, LONDON

THE Council of the Geological Society, London, has made the following awards:

The Wollaston Medal.—Frank Dawson Adams, emeritus professor of geology and paleontology in McGill University, for his researches on the pre-Cambrian rocks and on the influence of high temperatures and pressures on the properties of rocks at great depths in the earth's crust.

The Murchison Medal.—Harold Jeffreys, M.A., D.Sc., F.R.S., in recognition of the value of his researches on the constitution and physics of the earth's interior, and, in particular, of the deductions he has drawn from the analysis of records of distant earthquakes.

The Lyell Medal.—William Noel Benson, B.A., D.Sc., professor of geology in the University of Otago, N. Z., in recognition of the wide range and excellence of his geological researches, particularly in New Zealand.

The Prestwich Medal.—Samuel Hazzledine Warren, F.G.S., in recognition of his researches on the geology and archeology of East Anglia, particularly of the Lea Valley.

The Bigsby Medal.—Arthur E. Trueman, D.Sc., professor of geology in the University of Glasgow, in recognition of his outstanding contributions to the knowledge of paleontology and stratigraphy, particularly of the coal measures and the lias.

The Wollaston Donation Fund.—Ivan Sydney Double, M.Sc., for his work on the petrology of sedimentary rocks, especially the Tertiary rocks of the East of England, the glacial deposits, the chalk and the trias.

The Murchison Geological Fund.—Arthur Lennox Coulson, D.Sc., in recognition of his geological work in India, especially that concerned with earthquakes and meteorites and the survey of Rajputana.

A Moiety of the Lyell Geological Fund.—William Quarrier Kennedy, D.Sc., for his petrological work, especially in connection with the Tertiary complexes of the Hebrides and the metamorphic rocks of the Western Highlands.

A Second Moiety of the Lyell Fund.—Arthur Raistrick, Ph.D., M.Sc., for his researches on the minute structure and constitution of coal and on the past floras of Britain, as revealed by the study of peats.

SCIENTIFIC NOTES AND NEWS

At a dinner of the Board of Directors of the Research Corporation of New York, held on February 2 at the Faculty Club, Columbia University, awards of \$2,500 each for distinguished scientific achievement were made to Dr. Vannevar Bush, president of the Carnegie Institution of Washington, and to Professor Hugh S. Taylor, head of the department of chemistry of Princeton University. The award to Dr. Bush was in recognition of his invention of mathematical computing machines, and that to Dr. Taylor was in recognition of his research in the field of catalysis. The presentations were made by Dean J. W. Barker, of the School of Engineering of Columbia University. Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, introduced Dr. Bush, and Professor Harold C. Urey presented Dr. Taylor.

THE 1939 William Freeman Snow Medal of the American Social Hygiene Association has been awarded to Dr. Thomas Parran, surgeon general of the U. S. Public Health Service, "for his great contribution to the health and happiness of the American people through his persistent efforts against syphilis and the conditions which favor its spread." Presentation of the medal was made by Dr. Livingston Farrand as part of the National Social Hygiene Day program at the Hotel Mayflower, Washington, D. C., on February 1. Mrs. Franklin D. Roosevelt and Dr. Parran were the principal speakers.

MISS ALICE EASTWOOD, curator of botany in the California Academy of Sciences since 1892, was guest of honor at a luncheon at the Fairmont Hotel, San Francisco, on the occasion of her eightieth birthday on January 19. A correspondent writes: "The luncheon, attended by more than four hundred persons, partook of the nature of a civic event, and represented a spontaneous expression of admiration and esteem seldom accorded a scientific worker during his lifetime. Felicitations were read from scientific institutions and individual scientists in various parts of the world. Special recognition was given Miss Eastwood's historic action in rescuing the plant types and the records of the academy from the San Francisco disaster of 1906 (*cf. SCIENCE*, n.s., vol. 23, p. 834) and her subsequent energetic rebuilding of the herbarium to its present size of over 275,000 specimens. Miss Eastwood engages extensively in field collecting in addition to laboratory and administrative work, and it was pointed out at the luncheon that the growth of the herbarium

during 1938, the forty-seventh year of her curatorship, has been the greatest in the history of the academy."

THE gold medal of the Royal Astronomical Society, London, has been awarded to M. Bernard Lyot, of the Meudon Observatory, France, for his observations and photography of the solar corona in the absence of a total eclipse.

DR. F. M. BURNET, of the Walter and Eliza Hall Institute of Research in Pathology and Medicine, Melbourne, has been awarded the Walter Burfitt Prize, 1938, by the council of the Royal Society of New South Wales, for his work on virus diseases in man and animals.

THE Academy of Sciences of the U.S.S.R. has awarded the I. P. Pavlov Prize for 1938 to "Honored Worker in Science" I. S. Beritashvili, professor of physiology at Tbilisi University. Professor Beritashvili is the author of works on the physiology of the central nervous system, published in Russian and in other languages.

A RAMAN JUBILEE VOLUME has been published by the Indian Academy of Sciences to commemorate the fiftieth birthday of Sir C. V. Raman, president of the academy, and the completion of ten years of research on the Raman Effect. The volume contains thirty-eight original papers by distinguished men of science from many countries.

THE honorary degree of doctor of engineering was conferred on former President Herbert Hoover at the thirty-sixth annual dinner of the alumni of Stevens Institute of Technology, which was held at the Hotel Astor on February 3.

PROFESSOR GRIFFITH C. EVANS, of the department of mathematics of the University of California, was elected president of the American Mathematical Society at the recent annual meeting at Williamsburg, Va.

PROFESSOR WALTER MULFORD, head of the department of forestry of the College of Agriculture of the University of California, has been elected a fellow of the Society of American Foresters. There are only eighteen fellows of the society, which has a membership of 4,500.

AT the forty-first annual meeting of the Washington Academy of Sciences on January 19, the election of the following officers for 1939 was announced: President,

Charles E. Chambliss, Bureau of Plant Industry; *Corresponding Secretary*, Nathan R. Smith, Bureau of Plant Industry; *Recording Secretary*, Oscar S. Adams, Coast and Geodetic Survey; *Treasurer*, Henry G. Avers, Coast and Geodetic Survey; *Non-Resident Vice-presidents*, H. S. Graves, Yale School of Forestry, and R. B. Sosman, U. S. Steel Corporation; *Members of the Board of Managers for three years*, J. H. Hibben, Geophysical Laboratory, and G. Steiner, Bureau of Plant Industry; *Member of the Board to fill vacancy for two years*, H. C. Fuller, consulting chemist. *Resident Vice-presidents to represent each Affiliated Society* were elected as follows: Philosophical, F. G. Brickwedde; Anthropological, Henry B. Collins, Jr.; Biological, W. B. Bell; Chemical, B. H. Nicolet; Entomological, Austin H. Clark; National Geographic, Alexander Wetmore; Geological, H. D. Miser; Medical, Fred O. Coe; Historical, Allen C. Clark; Botanical, G. F. Gravatt; Archeological, Aleš Hrdlička; Foresters, W. A. Dayton; Washington Engineers, P. C. Whitney; Electrical Engineers, H. L. Curtis; Mechanical Engineers, H. L. Whittemore; Helminthological, E. W. Price; Bacteriological, L. A. Rogers, Military Engineers, William Bowie; Radio Engineers, J. H. Dellingen.

At the annual meeting of the Harvey Society, New York City, the following officers were elected for the year 1939-40: *President*, Philip E. Smith; *Vice-president*, Herbert S. Gasser; *Treasurer*, Kenneth Goodner; *Secretary*, Thomas Francis, Jr.; *Council*, Hans T. Clarke, William S. Tillett and N. Chandler Foot.

DR. MOYER SPRINGER FLEISHER, professor of bacteriology and hygiene in the School of Medicine of St. Louis University, has been dismissed from the chair which he has held since 1915. The Rev. Harry B. Crimmins, S.J., president of the university, has stated that Dr. Fleisher had been dismissed because of his sponsorship with others of a lecture on the Spanish war by a Loyalist speaker described as an "unfrocked" priest.

DR. HIPPOLYTE GRUENER, professor of chemistry at Flora Stone Mather College of Western Reserve University, with which he has been connected for forty-three years, retired on February 4.

DR. GEORGE E. UHLENBECK, professor of theoretical physics at the University of Utrecht, who is this year visiting professor of theoretical physics at Columbia University, will return to the University of Michigan as professor of physics, the appointment to take effect at the beginning of the next academic year. Professor Uhlenbeck was a member of the faculty of the University of Michigan from 1927 to 1935.

DR. E. G. PRINGSHEIM, professor of botany at the German University of Prague, has joined the depart-

ment of botany at Queen Mary College of the University of London. Dr. Pringsheim hopes to transfer to London his collection of pure cultures of algae.

DR. FRED L. MOORE, health officer in Tennessee, has been appointed associate professor in the department of preventive medicine and community health of the Long Island College of Medicine.

AN exchange of professorships for 1939-40 has been arranged between the University of Michigan and the University of Puerto Rico by which Assistant Professor William C. Steere, of the department of botany, will lecture at Puerto Rico and Professor Francisco M. Pagan will lecture at Ann Arbor.

DR. G. D. OSBORNE, of the University of Sydney, has been appointed a research associate at Harvard University. He has left for Cambridge, England, and later will proceed to Harvard to carry out experimental work in structural geology.

AT the annual meeting of the board of trustees of the Field Museum of Natural History, Chicago, Stanley Field was reelected president. He has held the office continually since 1909.

DR. RILEY H. GUTHRIE, chief executive officer of the Boston Psychopathic Hospital, has been appointed first assistant physician at Saint Elizabeths Hospital, Washington, D. C.

DR. RICHARD P. STRONG, professor of tropical medicine emeritus of Harvard University, delivered the Theobald Smith Memorial lecture before the New York Society of Tropical Medicine, which met at Cornell University Medical College, New York City, on January 20. He spoke on "Malarial Diseases in the Western Hemisphere."

DR. EDWARDS A. PARK, professor of pediatrics at the Johns Hopkins University School of Medicine, will deliver the fifth Harvey Society Lecture of the current series at the New York Academy of Medicine on February 16. He will speak on "The Pathology of Rickets with Particular Reference to the Changes at the Cartilage Shaft Junctions of the Growing Bones."

MAJOR GENERAL MERRITTE W. IRELAND, U.S.A., retired, who was surgeon general of the Army during the world war, will deliver the annual William Potter Memorial Lecture at Jefferson Medical College at 8:30 on the evening of Thursday, February 23. The subject of his address will be "Medicine's Debt to the U. S. Army."

DR. P. W. ZIMMERMAN, of the Boyce Thompson Institute, Yonkers, N. Y., gave an illustrated lecture on February 9 before the Lancaster Branch of the American Association for the Advancement of Science entitled "Chemical Secrets in Plant Growth."

SIR JOHN AMBROSE FLEMING, who is now in his nine-

tient year, on January 10 addressed the Physical Society, London, on "Physics and Physicists of the Eighteen-seventies." Part of the address was broadcast.

THE fourth International Congress of Comparative Pathology will be held in Rome in May, and will consist of three sections devoted respectively to human, veterinary and plant pathology. The subjects for discussion will be ultra-viruses, heredity in pathology, the function of combined antigens and retrogressive processes in plants. The proceedings will open with a reception on May 14 at Hotel Ambasciatori, and will end on May 20. The membership subscription of 250 lire covers the cost of all excursions and entertainments during the congress. The Compagnia Italiana Turismo (C.I.T.), 77, Regent Street, London, W.1, have been appointed travel agents, and will supply full information.

THE Council of the British Medical Association will call a national conference on nutrition in relation to national, including agricultural, policy. The dates provisionally selected for the conference are April 27, 28 and 29. In addition to the medical profession the conference will be representative of agricultural producers, home and oversea, as well as of industry and education.

THE October meeting of the Physics Club, Chicago, was opened by Professor R. A. Sawyer, who spoke on "The Spectrograph in the Iron and Steel Industry." In November the club acted as host to the American Physical Society, and the joint meeting, attended by about 350 members and guests, was addressed by Bertrand Russell on "Determinism in Physics." On December 20 Dr. Thomas C. Poulter addressed the club on "Extreme Pressures and the Investigation of Engineering Problems," and on January 17 Professor J. W. Beams, of the University of Virginia, spoke on "High Speed Centrifuging and Some of its Applications." The officers for the 1938-39 term are: *President*, Professor B. J. Spence, of Northwestern University; *Vice-president*, Professor J. S. Thompson, of Armour Institute of Technology; *Treasurer*, A. J. Klapperich, Peoples Gas Light and Coke Company; *Secretary*, B. J. Barmack, of the Commonwealth Edison Company. Professor W. S. Huxford, of Northwestern University, is chairman of the Program Committee. The club was organized in 1931 by Professor Arthur H. Compton and Dean H. G. Gale, of the University of Chicago. It has 24 members, mainly teachers, engineers and patent lawyers.

IT is announced that requests to the National Research Council Committee for Research in Problems of Sex for aid during the fiscal year beginning July 1, in the study of fundamental problems of sex and reproduction, must be received before April 1. They may be addressed to the chairman, Dr. Robert M.

Yerkes, Yale School of Medicine, New Haven, Conn. In addition to a statement of the problem, research plan or program, the committee desires information about the proposed method of attack, the auspices of investigation and the uses to be made of the sum requested. Preference, in accordance with present committee policy, is given to proposals for the study of neurological, psychobiological and behavioral problems.

THE University of Maryland has begun the erection of a new building for the medical school at Lombard and Greene Streets. The new building is being constructed with funds left to the university by the late Dr. Frank C. Bressler, an alumnus of the school, and money from the Federal Government. The structure will be known as the Frank C. Bressler Research Laboratory. Each of the five floors of the new building will occupy about 11,000 sq. ft. in addition to a sixth floor which will house the animals for the preclinical and clinical departments of the medical school. The first floor will be devoted to instruction and research in gross anatomy. In addition the Bressler Memorial Room on this floor will be used as a student's lounge. The second floor will house the department of histology and embryology in addition to a large lecture hall. The third floor will be occupied by the department of pharmacology. The fourth floor will be devoted to physiology and the fifth to research in clinical medicine and surgery. The respective departments will contain spacious teaching laboratories and many single, dual and triple research units. Occupancy of the new quarters is anticipated in the winter of 1939.

DR. S. S. GOLDWATER, Commissioner of Hospitals, has announced the withdrawal of the Cornell University Medical College from its affiliation with Welfare Hospital. The plan for the organization of the medical staff of Welfare Hospital is essentially unchanged, but instead of three college divisions covering the entire service, there will be two college divisions, to which all nominations will be made by Columbia University College of Physicians and Surgeons and the New York University College of Medicine, respectively, and an Open Division, to which members of the profession generally will be eligible. Dr. Goldwater has appointed Dr. Thomas A. McGoldrick, of Brooklyn, attending physician and director of the Medical Service on the Open Division, and Dr. Condict W. Cutler, of Manhattan, attending surgeon and director of the surgical service on the same division. Dr. McGoldrick is connected with St. Peter's Hospital; Dr. Cutler is a member of the surgical staff of Roosevelt Hospital. On the opening of Welfare Hospital, the Neurological Hospital on Welfare Island will be discontinued, but it is expected that many of the members of the Neurological Hospital staff will be invited to join the staff of Welfare Hospital.

DISCUSSION

THE SPIRAL STRUCTURE OF PROTOPLASM

THERE is now fairly general agreement among certain cytologists that chromosomes or their essential parts, the chromonemata, maintain a spiral structure in all stages. The recent work of Koshy¹ is one example in which this view is maintained.

The writer has investigated the structure of the iron bacterium, *Leptothrix ochracea*. This bacterium was fixed and treated in different ways. It was found that the bacterium is composed of series of longitudinal spirals. Spiral structure has also been observed by the writer in his photomicrographs of fixed preparations of green, filamentous, fresh-water algae.

Five years ago Seifriz² stated that the spiral habit seems to be a fundamental heritable quality of protoplasm.

While recently looking through Seifriz's book on protoplasm I was arrested by his photomicrograph³ of the quiescent protoplasm of a slime mold taken with a Spierer lens under dark-ground illumination. In some parts this picture shows complete spirals. Throughout the remaining parts of the picture structures typical of spirals in optical section are shown. For example, series of short parallel curves arranged one behind the other represent slightly obliquely placed spirals. Series of short, parallel lines arranged one behind the other represent spirals at right angles to the optical axis. A slight thickening at each end of the short lines shows the upward and downward coil in profile and results in slightly dumb-bell-like appearances. When seen end on, the spiral shows a comma-like appearance with the tail of the comma representing the spiral receding in depth. All these appearances are seen in Seifriz's photomicrograph and in the reproduction of it in his book. So it appears that this photomicrograph solves one of the major problems of protoplasm, for it shows the structure of the disperse phase to be spiral in the living state. Through Professor Seifriz's courtesy I have been able to examine the original photomicrograph.

With the spiral structure of Seifriz's photomicrograph as a guide the writer has examined living protoplasm microscopically with ordinary bright-ground illumination and conventional apochromatic lenses. The examination included living cells of stamen hairs of *Rhoeo discolor* and living epidermal cells of the bulb scale of the onion (*Allium cepa*). Spiral structure could be seen in each case. In the onion spiral structure was visible in the nucleus as well as the cytoplasm.

¹ T. K. Koshy, *Annals of Botany*, n.s., 1: 52, 56, 1937.

² W. Seifriz, *SCIENCE*, 77: 50, 1933; 78: 361, 1933.

³ W. Seifriz, "Protoplasm" (McGraw-Hill), fig. 119, 1936.

The observations on the spiral structure of protoplasm, which are outlined above, bring the nucleus and the cytoplasm into the same structural class. The disperse phase of the nucleus and of the cytoplasm is evidently spiral in structure.

The remarkable elasticity of protoplasm is explained by its spiral structure. An example of protoplasmic elasticity is given by Scarth.⁴ He showed that the nucleus of *Spirogyra* can be pushed by micromanipulation from one end of the cell to the other, but when it is released it immediately recoils to its original position.

The spiral structure of protoplasm can be correlated with several fundamental conceptions of life. One of these conceptions is that of crystalline character. The spiral is fundamentally a crystalline form with a screw-shaped axis. Accordingly, the spiral structure of protoplasm can be regarded as the basis of the crystalline conception of living material.

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THE STING OF THE ANT, PARAPONERA CLAVATA

IN an article, "The Sting of an Ant,"¹ I gave the history of the effect of the sting of a worker of the ponerine ant, *Paraponera clavata* Fabr., in British Guiana. The ant stung my knee over the patella through heavy khaki and produced paralyzing symptoms, then a large and persistent blister. The well-founded reputation the sting of this ant has in South America for producing severe systemic symptoms in humans was described.²

In discussing the effects of the stings of this species with entomologists and other scientists I was puzzled by accounts of their experiences in Central America, especially Panama. Several persons described being stung by these ants without incurring such severe symptoms as resulted from stings in South America. The stings, however, were always equal to a bad wasp sting. This past summer on Barro Colorado Island in the Panama Canal Zone I was stung by this species³

⁴ G. W. Scarth, *Protoplasma*, 2: 194, 1927.

¹ *Am. Jour. Trop. Med.*, 17: 765-768, Fig. 1, 1937.

² In the "Medical Report of the Hamilton Rice Seventh Expedition to the Amazon, in Conjunction with the Department of Tropical Medicine of Harvard University, 1924-25," Harvard University Press, Cambridge Massachusetts, 1926, Dr. J. Bequaert has reviewed (pp. 250-253) the effects of the stings of this ant upon natives and whites in the Amazonian basin. The worker ant is well figured on page 253 (Fig. 8). The reputation this ant has among the natives and the effects of the sting upon whites recorded by Dr. Bequaert are added proof that I was not unusually susceptible or allergic to such poison in British Guiana.

³ The ant is called "chacha" by the Panamanians and

and the effect seems worthy of comparison with that previously described. Conditions under which I was stung were comparable, to the extent that both times I was in good health and accustomed to the stings of numerous kinds of ants.

June 25, 1938, at 2:19 P.M., while excavating the nest of the ant *Sericomyrmex amabalis* Wheeler, I felt a sting comparable to a severe wasp sting on the skin at the junction of the middle and upper third of the left forearm opposite the medial aspect of the biceps muscle. I was wearing a short-sleeved jacket and reflexively brushed the sleeve, whereupon a dealate female *Paraponera clavata* 27 mm. long tumbled to the ground. She had climbed up the sleeve as it momentarily touched the ground and the course of the sting could be followed into the skin as a reddish line 2-3 mm. long on a slight edema resembling that following a mosquito bite. No reaction of the surrounding tissues other than those described above had occurred eight minutes later. At 2:41 an urticarial-like lesion with a central edematous area 2 mm. in diameter and an erythematous halo approximately 40-50 mm. in diameter had appeared.

There was a dull, burning sensation associated with the lesion. By 5:00 P.M. an oval area fully 150 mm long on the inner surface of the forearm was reddened peripherally. A distinctly yellowish edematous area about 100 mm long occupied the center of the reddened area. The burning sensation continued. No systemic reaction was noticed and there was no evidence of lymphangitis extending toward the axilla nor any tenderness or enlargement of the axillary lymph nodes at any time. At 7:30 the lesion was disappearing, though the burning sensation was still present. No medication was applied to the lesion at any time, except that the customary evening shower with soap was taken just before 5:00 P.M. The next morning the area was slightly reddened but not painful. The process gradually disappeared, leaving the arm completely normal.

The effect of this sting of the Panamanian ant strikingly contrasts with that of the Guianan ant is common in the rain forests of this region. Nesting and other habits are essentially similar to those in South America. This species excavates irregular chambers a few centimeters in diameter in the soil at the base of a tree, frequently a buttressed tree. From the nest a soil-covered chimney several centimeters in diameter is usually built to a height of sometimes 10-30 cm. This chimney may be washed down during heavy rains, leaving an opening to the nest occasionally 10 cm in greatest diameter. When their tree is sharply rapped or when the surrounding soil is stamped the ants come "boiling" out and wildly dash about in search for the disturber. Any moving animal in their path is viciously stung. Those ants of a Panamanian nest did not climb trees in their search for a disturber higher than 60 cm, usually about 10 cm. In South America I often found them climbing trees to a height of two meters.

previously described. Both belong to the same species and have not been separated, even as different subspecies or varieties, though numerous specimens from both Central and South America have been examined by myrmecologists. The fact that it was a female and not a worker ant which stung me in Panama means that fully as much, if not more, poison was probably injected. Female ants are larger and commonly the sting is more intense than in workers. She had every opportunity to inject a full dose of poison directly into the flesh, while the Guianan worker stung through heavy khaki cloth and was brushed off almost at the time it started to sting. The Panamanian sting, on the medial surface of the forearm, was in an ideal place to be absorbed quickly into the axillary lymph nodes and produce systemic disturbances, while the Guianan sting was over the patella where the blood supply and drainage would be relatively poor.⁴ Yet in the Panamanian sting recovery was complete in a few hours; in the Guianan it took over a week.

This difference in virulence of sting in the same species of ant suggests a physiological difference unaccompanied by obvious morphological characters which seems not to have been recorded among ants or related insects.

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A REVERSED CRYPTOBRANCHUS

A RECENT article in SCIENCE by Helen A. Wragg on a reversed cat leads to this brief report on the same situation in a large female *Cryptobranchus*. It was discovered this fall during routine laboratory dissections. As far as can be ascertained, the reversal is complete, with stomach and spleen on the animal's right rather than on its left side. The position of the gall bladder and duodenum has shifted to the left. This condition not only shows itself in the digestive tract, but is obvious in the position of the heart within the pericardial sac, and the relation of the portions of the heart to each other. It is reflected again in the distribution of the intestinal blood vessels. The animal was a perfect specimen and all organs were normal in size and appearance.

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VEGETATIVE REPRODUCTION OF SQUASH TYPES

VEGETATIVE reproduction of squash types, *Cucurbita* spp., has been developed and is now being used to sup-

⁴ This probably accounts for the localized lesion which resulted compared with the severe systemic disturbance produced by stings in other parts of the body in the usual South American case.

plement sexual reproduction methods in our squash-breeding studies in Puerto Rico. Vigorous 5- to 7-node cuttings with swollen root buds at several nodes have rooted and successfully established normal plants under field conditions; under favorable soil-moisture conditions in the field, successful propagation in as high as 90 per cent. of the cuttings was not unusual. All leaves on each cutting were left intact, the youngest leaf being usually approximately one third full grown. On planting, the entire cutting was covered with soil except the youngest leaf and the vegetative growing point subtended by it. No shading was required nor was the application of growth-promoting substances or other special growth aids necessary. It was observed that

plants thus propagated grew more rapidly and fruited earlier than plants produced from seed.

This vegetative propagation permits the rapid and easy establishment of clonal lines of squash and facilitates physiological studies for which plants with a high degree of uniformity are essential. By making possible the immediate propagation of superior commercial types of greater uniformity and higher quality this method of propagation has an economic application in the tropics and subtropics, where heterogenous populations of squash exist.

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BOOKS AND LITERATURE

Sulfanilamide Therapy of Bacterial Infections. By R. R. MELLON, PAUL GROSS and FRANK B. COOPER. Charles C Thomas Company, Springfield, Ill., 1938.

THE background of the discovery of prontosil in 1935 by G. Domagk remains clouded in obscurity. Of the many prior compounds that must have been studied by Domagk, in collaboration with the chemists Mietzsch and Klarer at the I. G. Dye Works in Germany, we have no record.

The entire development has been characterized by hasty application of laboratory findings to clinical practice, a fault partially justified by the life-saving nature of the therapy in many cases. Soon after Domagk's announcement of prontosil, Tréfouel, Nitti and Bovet at the Pasteur Institute demonstrated that sulfanilamide was an active fraction of the prontosil molecule, and subsequent work has shown it to be more active and less toxic than prontosil.

Originally believed by Domagk to be specific for streptococcal infections, work from various laboratories showed that the following experimental infections could to varying extents also be influenced by this type of therapy: Meningococcus, pneumococcus, staphylococcus, typhoid bacillus, Welch bacillus. Clinical trial, followed by laboratory studies, brought the gonococcus and *B. abortus* within the pale of curative action. Slight action has been found upon animals infected with choriomeningitis virus, canine distemper virus, influenza virus and the virus of lymphogranuloma inguinale. Much optimism for the future of chemotherapy can be drawn from this imposing start and from the fact that some sulfonamide compounds exhibit special activity against certain of these infections. The infections against which the most marked action can be shown in the laboratory—streptococcus and meningococcus—have been the ones yielding the most favorable results in the clinic.

It was inevitable that a wide-spread search would be begun for new compounds, and a baffling number have already been reported in the scientific and patent literature. Drs. Mellon, Gross and Cooper list several pages of them, including the more active diphenyl sulfones.

Considerable space is devoted by the authors to the various phases of mechanism of curative action. Bacteriostatic effects of sulfanilamide have been demonstrated both in culture media and in body fluids. This effect, although definite, is weak. The rôle of neutralization of bacterial toxins and of interference with capsule formation remains to be established. There is general agreement that the drug acts on the organism in some way whereby the natural defense forces of the body are rendered better able to cope with the infection. Potentiation by the drug of the action of anti-serum has been demonstrated both in culture and in the infected animal. More satisfying evidence is needed to clarify the mechanism of action, although it must be remembered that the problem of mechanism in the case of most other chemotherapeutic drugs has resisted attempts at solution. Interesting is the demonstration *in vivo* of the "antitoxin" action of some of these sulfur compounds.

Pharmacological and pathological studies of these new compounds have regrettably lagged behind therapeutic investigations, and such important issues as chronic toxicity effects and metabolic studies remain to be more fully explored. It has been established that excretion of sulfanilamide is chiefly through the urine, partially in the free state, and in some species (including man) partially acetylated. Excretion is rapid, and the major part of the drug can be recovered from the urine within 12 hours after an oral dose.

Experimental evidence of curative action for strepto-

coccal infections has been obtained largely from mice. As the authors point out, comparison of results is difficult because of the many variable factors in such experiments which have not been standardized. However, this demonstration of curative action from many laboratories under many different conditions affords a solid experimental foundation for the future progress in this field. As evidence that the drug does not kill the organisms in the body, viable streptococci can be recovered from animals apparently cured; delayed death is also frequent after cessation of therapy. Unexplained is the evidence that drug therapy is more effective against organisms of high virulence than against those of low virulence. It is also to be noted that relatively large doses of sulfanilamide (approximately one fifth of the tolerated dose) are required to bring about high percentages of cures in infected mice.

The authors review the various reports dealing with hemolytic streptococcal infections in man treated with sulfanilamide and related compounds. Included are their own experiences in this field. While the early enthusiasm will undoubtedly suffer some later discount, the striking results obtained in erysipelas, streptococcal septicemia and puerperal sepsis testify to a therapeutic effect, and the recovery of the majority of cases of streptococcal meningitis, hitherto highly fatal, must carry conviction even to the doubters.

The results in cases of alpha streptococcus (*viridans*) infections have unfortunately shown no curative action.

Experimental work upon meningococcal infections in mice showed sulfanilamide to have marked curative action. This action was independent of immunological type, but varied with different strains. The best laboratory results have come from the combined use of drug and specific antiserum. Clinical experience, while favorable, is as yet insufficient for an evaluation of this therapy.

The action of sulfanilamide in pneumococcal infections in mice is much weaker than upon streptococci. Curative effects are pronounced in rats, however, either when infected intraperitoneally or when a pulmonary lesion is produced by intratracheal injection of the organisms. Experiments indicate a synergism between drug and serum therapy in this infection also. No comment can be made on the few cases of pneumococcus infections in humans on which information is available concerning this therapy. Significant, however, are the recent results reported with drug plus serum in pneumococcal meningitis. Also promising are the results with a pyridine compound of sulfanilamide in pneumococcus infections, recently reported.

Staphylococcal infections in animals respond slightly to sulfanilamide therapy. Some of the newer compounds were found more active, but those derivatives studied (sulfanilyl sulfanilamide) possess neuro-

tropic side actions in man that discourage their clinical trial. Results with sulfanilamide in staphylococcal infections in man have not been promising.

Clinical evidence indicates that sulfanilamide therapy offers hope in the treatment of undulant fever, another disease for which no effective therapy previously existed.

Perhaps the widest use of sulfanilamide has occurred in the treatment of gonorrhea. Many reports are available, unfortunately poorly controlled or uncontrolled. The many favorable reports speak for a beneficial effect, the limitations of which must be established by further experience. Similar remarks can be made in reference to its use as a urinary antiseptic.

The wide-spread use of sulfanilamide soon brought to attention that the drug was not harmless. It was also found that the symptoms of toxicity in man differed considerably from those in mice and rats. In these animals 1.0 gm per kilo is tolerated for weeks without ill effects. In man the usual daily doses of 0.02 to 0.1 gm may cause (1) cyanosis, the exact nature of which remains to be determined, (2) fever, often delayed several days from onset of therapy, (3) acidosis, the mechanism of which is unexplained, (4) dermatitis of various types, one of which follows exposure to sunlight, (5) blood changes, particularly hemolytic anemia and neutropenia; a few instances of agranulocytosis have been attributed to this drug, (6) dizziness and digestive symptoms, common but not serious.

With the development of methods for the determination of sulfanilamide, attempts have been made to correlate the concentration reached in the body fluids, with therapeutic results or with toxic manifestations. As it has not yet been established whether these effects are the result of sulfanilamide itself, or other products formed from it in the body, the limitations of such investigation must be borne in mind. Important, however, is the rapidity with which the drug penetrates to all parts of the body, even when administered orally.

The authors describe experiments from their laboratory whereby accessory factors of body fitness are of importance in the fight against infection. A beginning has been made in this direction.

There is justifiable optimism from the experimental results with new compounds. Compounds with many times the activity of sulfanilamide are being obtained. Derivatives with specialized action against certain infections have been found. The field is still in its infancy, but the outlook for better and safer compounds and for new conquests in the field of infectious diseases is indeed bright.

From the context of this review it is evident that most phases of this subject can be treated with little finality at the present time. In a field as rapidly mov-

ing as bacterial chemotherapy a book is necessarily at a disadvantage in that important developments are prone to follow closely upon its heels. The authors have attempted in some way to offset this disadvantage by adding an addendum to the book. However, for those interested it is desirable to have the pertinent

facts in this important field collected together at frequent intervals. The authors are well suited to this task because of their experience both in the laboratory and in the clinic.

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SPECIAL ARTICLES

HYDROSOLS AND ELECTROLYTIC IONS

WHILE electrodialyzing some solutions of clay in water and in dilute acids and alkalies, a curious relation has appeared which throws light on the association of the electrolytic ions with certain of the hydrosols which may be present.

If a montmorillonite clay be brought to equilibrium with a dilute acid solution (say 1 per cent. hydrochloric) and then filtered and the solution electrodialyzed, it will be found that the silica is carried *equally* in both directions. Other ions present are usually found unequally in anode and cathode liquors, but the silica is strictly amphoteric, it either consists of equal numbers of anions and cations or is a carrier of equal numbers of such ions. After the effect was first noted, other experiments (25 in all) were made at different acid and alkali concentrations and on various clays including soil, all confirming the original findings or indicating necessary conditions.

The dialyzer used was an ordinary Mattson with the electrodes supplied replaced by others of sheet platinum. Cellophane membranes enclose the cell $1 \times 10 \times 15$ cm. Electrode compartments are $3 \times 10 \times 15$ cm. The current used was from a 116-volt line and held to below one ampere by a 100-watt lamp in series. Anode and cathode liquors were replaced by fresh distilled water four times at hourly intervals and each analyzed separately.

The clay solutions were prepared by digesting about 30 grams of 150 mesh (0.1mm) clay in two liters of acid solution for fifty hours at about 90° C. with frequent stirring. A few acid clays and acid-treated adsorbent bentonites require twice as long to bring to equilibrium. About 400 cc of the filtrate was evaporated to 150 cc for the dialysis. The total recoverable solids is from 1.5 to 5 grams per liter of solution according to acid concentration. At equilibrium, there is always free and adsorbed acid present as well as salts in solution.

Electrodialysis of a solution that has not come to equilibrium with a clay or soil shows an unequal partition of silica; an acid clay shows an excess of silica transported as cations, while a slightly alkaline soil gives a slight excess of silica as anions.

The first ions removed are H^+ and Cl^- . After the first hour the cations are largely the R_2O_3 bases.

If an electrodialysis of an equilibrium solution is stopped at an early stage and the three solutions analyzed, the silica will be found in equal amounts in anode and cathode liquors as though run to completion. When a pure silica gel solution is electrodialyzed, the silica is equally divided. An alkaline solution of a neutral clay (Florida fuller's earth) gave four times as much anion silica as cation silica. The same solution neutralized with HCl just before dialysis showed an equal division (49 vs 51 per cent.) of silica. A water solution of an alkaline bentonite (Wyoming swelling, 1.2 grams per liter) dialyzed 64.6+ vs 33.5- without and 48.1 vs 43.7- with HCl added before dialysis. But the same solution with NaCl added before dialysis gave for +silica 95.5 vs -4.5. When insufficient ions are present electrodialysis gives a precipitate of silica in the cell.

It seems hardly possible that silica in solution can consist of equal numbers of anions and cations. The alternative seems to be that other charged ions are adsorbed in equal numbers on the silica and supply the motive power in a potential gradient. Anions and cations are present in necessarily equal numbers, hence in equilibrium clay or soil solutions they must also adsorb in equal numbers on the silica hydrosol micellae with which the cations were previously associated. Certain added ions prevent equal adsorption, others do not.

These results will be given in more detail in a later paper. It would be of interest to know whether similar relations obtain in other fields, say in the relation of the silver halides to the gelatine in photographic emulsions, of ions to hydrosols in sugar solutions, in plant saps and the like.

P. G. NUTTING

U. S. GEOLOGICAL SURVEY

THE ASEXUAL LIFE CYCLE OF THE AVIAN MALARIA PARASITE, PLASMODIUM CIRCUMFLEXUM¹

EVIDENCE has been accumulating for some time that the life-cycle of the malaria parasite in the vertebrate is less simple than has been thought and that the plasmodia are able to parasitize not only the erythrocytes

¹ From the Department of Zoology, Syracuse University, Syracuse, N. Y.

but also other types of vascular or phagocytic cells. This was first shown to be true of *Plasmodium elongatum* by Raffaele² and shortly afterward by Huff and Bloom.³ This species of avian plasmodium may be found in any type of blood or blood-forming cell, although it much prefers the erythrocytes. Since the work on this species, Raffaele,⁴ Kikuth and Mudrow⁵ and James and Tate⁶ have been able to demonstrate that there are also exoerythrocytic stages in *Plasmodium praecox*, (*relictum*), *cathemerium* and *gallinaceum*, respectively; Kikuth⁷ in a recent paper with Mudrow has given a good summary of our knowledge of such stages to date. He remarks, however, that although he has looked for stages of this sort in *Plasmodium circumflexum* infections he has not as yet been able to find them. It may be noted here that the three species last named differ from *Elongatum* in that the parasites occur in the cells of the reticulo-endothelial system and, of course, in the red cells also, rather than in all the blood and blood-forming cells.

The authors of the present paper have for some time been engaged in a study of the immunological characteristics of various strains of *Plasmodium circumflexum*, and as a somewhat incidental part of the study a number of infected birds (female canaries) have been examined for possible exoerythrocytic stages. As a result it is possible to say that such stages occur in at least four strains, and they have so far been found in the lungs, spleen, liver, heart muscle, bone marrow and brain, but not in all the birds examined. Of the thirty-six birds in which they have been looked for, they were seen in fifteen of twenty-one active cases, and not in any of the fifteen chronic cases. Of the four strains, one originated in Germany, one in Cape Cod and the other two in Syracuse. Our results suggest that stages in other than the red cells are most likely to be found soon after parasites first appear in the peripheral blood, and prolonged search may be necessary to find them. Once found, however, they are frequently found to occur in localized areas in great numbers.

The question has recently been raised by Hegner and Wolfson⁸ as to whether, in certain cases at least, the parasites found in cells of the reticulo-endothelial system and interpreted as part of the asexual cycle of malaria, are not actually *Toxoplasma*. This is quite possible under some circumstances, for *Toxoplasma* may spread rapidly in the laboratory once it is present at all, and some stages strongly resemble what has

² Raffaele, *Riv. di Mal.*, 13: 332-337 and 402, 1934.

³ Huff and Bloom, *Jour. Inf. Dis.*, 57: 315-336, 1935.

⁴ Raffaele, *Riv. di Mal.*, 15 (5), Sez. 1, 3-9, 1936.

⁵ Kikuth and Mudrow, *Klin. Wschr.*, 16 (48): 1690-1691, 1937.

⁶ James and Tate, *Nature*, 139: 545, 1937.

⁷ Kikuth and Mudrow, *Zentralbl. Bakt.*, I Orig., 142: 113-132, 1938.

⁸ Hegner and Wolfson, *Amer. Jour. Hyg.*, 27: 212-220.

been regarded and figured as exoerythrocytic schizogony in the avian malaria species mentioned above. It should be pointed out however that *Toxoplasma*, usually, if not always reproduces by binary fission. In our experience, *Toxoplasma* has occurred only once in laboratory canaries, and in this case it was apparently acquired from English sparrows. The infection spread very rapidly among the sparrows and killed a number of them, but it had no connection with malaria at all, since most of the sparrows had been previously shown to be free from malaria infection of any kind. We have seen no evidence of *Toxoplasma* in canaries since, although numerous birds have been studied and autopsied over a period of several years. For this reason and because the stages which we have found in the *circumflexum*-infected birds mentioned above are much like those seen by the other investigators already cited in connection with the work on *praecox*, *cathemerium* and *gallinaceum*, we believe that in *circumflexum* also it may be regarded as demonstrated that exoerythrocytic stages occur. From the evidence already existing it seems likely that similar stages will be found in the other species of avian malaria, and quite possibly in monkey and human malaria also. It also makes it probable that the biological relationship between the malaria parasites and *Hemoproteus* and *Leucotozoan* is closer than has been thought.

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THE PREVENTION OF TOXIC MANIFESTATIONS OF AN EXCESS OF VITAMIN B₁ BY SUPPLEMENTS OF MANGANESE TO THE DIET¹

IN an earlier publication we reported that the addition of supplements, to our standard adequate diet, of vitamin B₁ in amounts of 50 international units per rat per day resulted after one generation in interference with lactation, loss of the maternal instinct, cannibalism and progressive loss of fertility.² Our standard diet contains rolled oats, meat scrap and bone meal, dried skimmed milk, fresh greens, fresh milk, salt, cod liver oil and brewer's yeast (in amounts equivalent to 2 or 3 international units per rat per day). With reduction in the excess amount of vitamin B₁ to 20 units or the elimination of the excess supplements of vitamin B₁ for short periods, normal lactation and normal interest in the young was restored. When the vitamin B₁ content was again increased the same toxic effects were observed. Further study completely confirmed our earlier findings. With supplements daily of 30 units of vitamin B₁, progressive decrease in

¹ From the Laboratory Division, Montefiore Hospital, New York City.

² D. Perla, *Proc. Soc. Exp. Biol. and Med.*, 37: 169, 1937.

fertility also occurred with a moderate incidence of loss of litters due to cannibalism. After five generations breeding markedly decreased.

In view of the fact that Williams³ stated that as much as from 160 to 1,000 γ of vitamin B₁ daily could be given without any toxic effects when rats were fed a Sherman breeding diet (one third whole milk and two thirds whole wheat), it seemed probable to us that interference with some other essential factor in the diet may have induced the manifestations observed in our experiments.

It is known that deficiency of manganese in the diet presents similar toxic effects on the maternal instinct and reproduction.⁴ It was reasoned that perhaps manganese is essential as an oxidative catalyst in the utilization of vitamin B₁ in the tissues. If this is so the available manganese in the tissues may be exhausted by an excess of vitamin B₁, and analogous manifestations would occur as is observed with a deficiency of manganese.

To test our hypothesis we added small amounts of manganese to the diet. Rats which had shown loss of maternal instinct and cannibalism now bred and raised normal litters. The studies were then extended. Rats were raised on the normal diet and given par-

enterally 200 units of vitamin B₁ daily. Others were given the same diet and vitamin B₁, but the diet was supplemented with 2 mg of manganese as MnCl₂ per day per rat. In those receiving the vitamin B₁ alone, cannibalism and interference with lactation occurred in a high percentage in the P and F₁ generation in successive litters (13 of 22 litters). In those receiving in addition supplements of manganese in the diet, none of these toxic symptoms were apparent and the normal maternal instinct and normal lactation were preserved (in a total of 25 litters). In our normal stock observed during the same period no loss of litters occurred.

These results demonstrate that manganese is essential in the utilization of vitamin B₁ in the tissues and is intimately bound up with the role of vitamin B₁ in the physiology of the organisms. It also suggests that variations in certain constituents of the diet, such as manganese, may greatly affect the vitamin B₁ requirement. With the use of large amounts of vitamin B₁ in therapy, an adequate supply of manganese must be made available. As yet it is not known whether the protective effects observed with manganese are specific for manganese as such or would be obtained with other oxidative catalytic metals such as cobalt or copper.⁵

DAVID PERLA

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE USE OF THE NEON GLOW LAMP IN THE PHYSIOLOGICAL LABORATORY FOR THE ELIMINATION OF MAKE INDUCTION SHOCKS

In the use of an induction coil as a source of electrical stimuli for living tissue, in the physiological laboratory, it is often desirable to prevent the "make shocks" (the E.M.F. induced in the secondary coil when the primary circuit is closed) from passing through the tissue, and various devices are in use for short-circuiting the secondary coil while the primary circuit is being closed. While entirely satisfactory in performance, such devices, if arranged to operate automatically, are generally complicated and expensive.

While seeking a simple means of automatically eliminating make shocks, that would be suitable for use in the students' laboratory, we hit upon the idea of connecting a neon glow lamp in series in the secondary circuit. It happens that the Harvard coil and some of the other coils manufactured for physiological

use in this country when used with one or two dry cells give make shocks that are too weak to ionize the gas in the lamp and are, therefore, not conducted through it; the break shocks, however, are readily conducted.

Since there is some loss of energy in the lamp, due to resistance, a high capacity lamp without auxiliary resistance gives best results. We have provided our students with two-watt glow lamps without resistance in the base. For convenience and sturdiness of mounting, lamps with radiatron base were obtained on special order from the General Electric Vapor Lamp Company of Hoboken, N. J. The sockets are recessed in small cast-iron blocks; suitable binding posts are provided for making connections.

The method has but one serious disadvantage. Since the secondary is not short-circuited and is open-circuited only for low voltage impulses, chatter or vibration of the key used to control the primary circuit must be avoided at the make; otherwise a succession of rapid makes and breaks occurs which induces a high enough potential in the secondary to pass through the lamp. Chatter is easily avoided with hand-operated keys, and electrically operated keys or relays should, in any case, be so designed as to close without chatter. Inciden-

³ R. R. Williams and T. D. Spies, "Vitamin B₁ and its Use in Medicine," p 286. Macmillan Company, New York, 1938.

⁴ E. R. Orent and E. V. McCollum, *Jour. Biol. Chem.*, 92: 651, 1931.

⁵ The vitamin B₁ for these experiments was kindly furnished by the Department of Medical Research of the Winthrop Chemical Company.

tally, since the lamp glows each time an impulse is conducted, chatter of the key and other defects in the electrical system are easily detected. It may be, also, that making the electrical impulse "visible" will prove to have advantages for teaching purposes.

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USE OF THE LUNDEGÅRDH SPECTROGRAPHIC METHOD

A SURVEY of the spectrographic methods used in this country for the quantitative determination of small quantities of mineral substances reveals the fact that the Lundegårdh¹ method is not employed here. In this method the emission spectrum is excited by means of the flame of a special air-acetylene burner, for which the acetylene and the air are supplied at constant pressure. The air is forced through a few milliliters of the solution of the substance under analysis, thus spraying the solution into the flame uniformly. In this way the spectra of 32 elements at different concentrations have been photographed and, from the intensity of a certain line in each, it has been found possible to make fairly rapid, quantitative determinations of great accuracy and dependability. This is especially true when the Lundegårdh system of constructing both a plate correction curve and a concentration curve for each plate is followed.

The problem of the determination of the mineral constituents of citrus fruits and of some vegetables has been in progress in this laboratory for some time. The material has been dried and ashed quantitatively and then the per cent. of calcium, copper, iron, magnesium, manganese and phosphate in the ash has been determined by micro-photometric or micro-volumetric methods. It has been necessary to use large quantities of the materials in order to obtain sufficient ash to carry through the above analyses. For instance, in the case of orange juice, a liter would be required. This process is long, subject to many sources of error, and dependent upon complicated technique, all of which are in great contrast to the Lundegårdh spectrographic method.

Professor Lundegårdh very kindly gave me the opportunity of working in his laboratory at the Agricultural College of Sweden this summer, and I was able to do some preliminary work on the determination of the mineral constituents of orange juice. By concentrating 100 ml of the juice nearly ten times and oxidizing the organic matter by one of several methods, for instance, by nitric acid and perhydrol, it was possible to obtain results for copper, iron and man-

¹ H. Lundegårdh, "Die quantitative Spektralanalyse der Elemente II," Jena, 1934; *Lantbrukskōgskōs Annaler*, Vol. 3, s. 49.

ganese which were of the same order as our photometric methods. (See Table I.)

TABLE I
MILLEMOLS PER LITER JUICE

Oranges	Copper	Iron	Manganese	Method
Blue Goose	0.0061	0.042	0.0039	Lundegårdh
Sunkist	0.0072	0.030	0.0039	"
Valencia	0.0065	0.030	0.0043	"
South Africa	0.0068	0.043	0.0033	"
Average ² for California and Florida oranges	0.0069	0.025	0.0044	Micro-photometric

² Honors paper of Annette Florence, Wellesley College, 1936.

It was also possible to determine such metals as potassium and calcium which are present in much larger quantities without concentrating the juice, but by refluxing with hydrochloric acid, filtering out the solid material—really a form of wet ashing—and then spraying into the flame.

In this laboratory at the present time we are continuing the study of the various ways of preparing these solutions, as well as the spectrographic and photometric procedures. It is especially important to carry out careful blank determinations because of the possible contamination from chemicals and apparatus when such small quantities of some elements are to be determined. We also expect to use this method for the determination of mineral constituents in various biological materials, for which it is particularly well adapted.

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